# U. S. NAVAL AIR DEVELOPMENT CENTER
## JOHNSVILLE, PENNSYLVANIA

Aviation Medical Acceleration Laboratory

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**Recording Instrument for Environmental Testing of Biological Specimens**

Bureau of Naval Weapons
Weptask R360 FR102/2021/R01 10 1001 (50-3-04)


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## SUMMARY

This report describes the modification of a strip chart recorder for use in recording, long term, the conditions of an environmental system used for subjecting animals to gas mixtures in which the oxygen content is varied. Provisions are made for recording four pressures, six temperatures and four 10 mv signals which in this case consist of two gas flowmeters and oxygen and carbon dioxide analysis.

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## INTRODUCTION

Interest in the habitability of the space environment has led to a need for the development of life support systems adaptable to transport as part of the payload of rockets. The problem of the design of such systems is complicated by the fact that the organism as well as the space environment tends to change the previously set conditions of the life support system. For example, increased physical activity by the organism may bring forth transitory changes in the composition of the breathing gas, and in the system pressure, while the pressure differential that exists across the wall of the capsule will cause an outboard leak. A partial answer to some of the questions on life support can be obtained by simulation tests and accordingly an environmental system for making such tests on the life support systems of small space bio-probes has been constructed. This report concerns the means for obtaining data from the operation of this system.

## READ-OUT SYSTEM

The basic recording instrument was a sixteen-channel Brown Electronik Recorder having a full scale sensitivity of 0-10 mv and a pen speed of 4-1/2 seconds. The instrument was originally designed to read-out ten channels of temperature as measured by resistance bulbs; two for relative humidity from the M-H multiple grid circuit and four for pressure from strain gages. In this mode of operation, temperature was obtained from a Wheatstone bridge whose active arm was a resistance bulb that was switched in for the respective channels. Relative humidity was read from another bridge in much the same manner. Pressure was read from transducers having 4 active arm Wheatstone bridges of 350 $\Omega$ with zero and span adjustments provided in the recorder. Excitation for all circuits was provided in the recorder and the output of each channel was amplified on a common servo amplifier that drove a balancing motor. The balancing motor drove the instrument indicator which in effect showed the difference between the incoming signal and a reference signal. The initial line-up of data channels was as follows:

1. Dry bulb chamber
2. Wet bulb chamber
3. Inlet scrubber
4. Outlet scrubber
5. Outlet pump
6. Room
7. Accessory
8. "
9. "
10. "

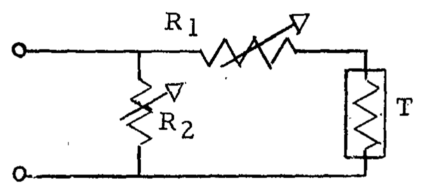
Temperature

11. Relative Humidity
12. " "
13. $O_2$ Cylinder, 0-2000 PSI
14. Chamber, ± 15 PSID
15. Chamber, ± 1 PSID
16. Accessory ± 1 PSID

Pressure

## MODIFICATION OF TEMPERATURE CHANNELS

A modification in the temperature channel was indicated from the start. The resistance bulbs for which these channels were constructed are rather fragile and they are physically large. It was decided, therefore, to replace them with thermistors. The resistance bulbs provided for the instrument were selected for a temperature range of 20° - 30°C, and in order to match a thermistor to the bridge in this range and sensitivity, series and parallel resistances were used. These took the form of two trimpots for each thermistor as follows:




Since the slopes of the temperature-resistance curves for resistance bulbs and thermistors are opposing, thermistors increasing resistance with temperature, it was necessary to reverse polarity at the input to the servo-amplifier. Figure 1 shows the trimpots mounted to the right below the two relay cans. A parallel-series unit is available for each channel.

When the modification (Figure 1) was completed, it became necessary to calibrate for temperature. Since unmatched thermistors were used, each channel had to be calibrated individually. From the diagram above, it may be surmised that $R_1$ will affect principally sensitivity and $R_2$ range, but in practice, these resistances are interdependent. A calibration procedure was therefore adopted which brought a given channel into the proper range and sensitivity with a minimum amount of manipulation.

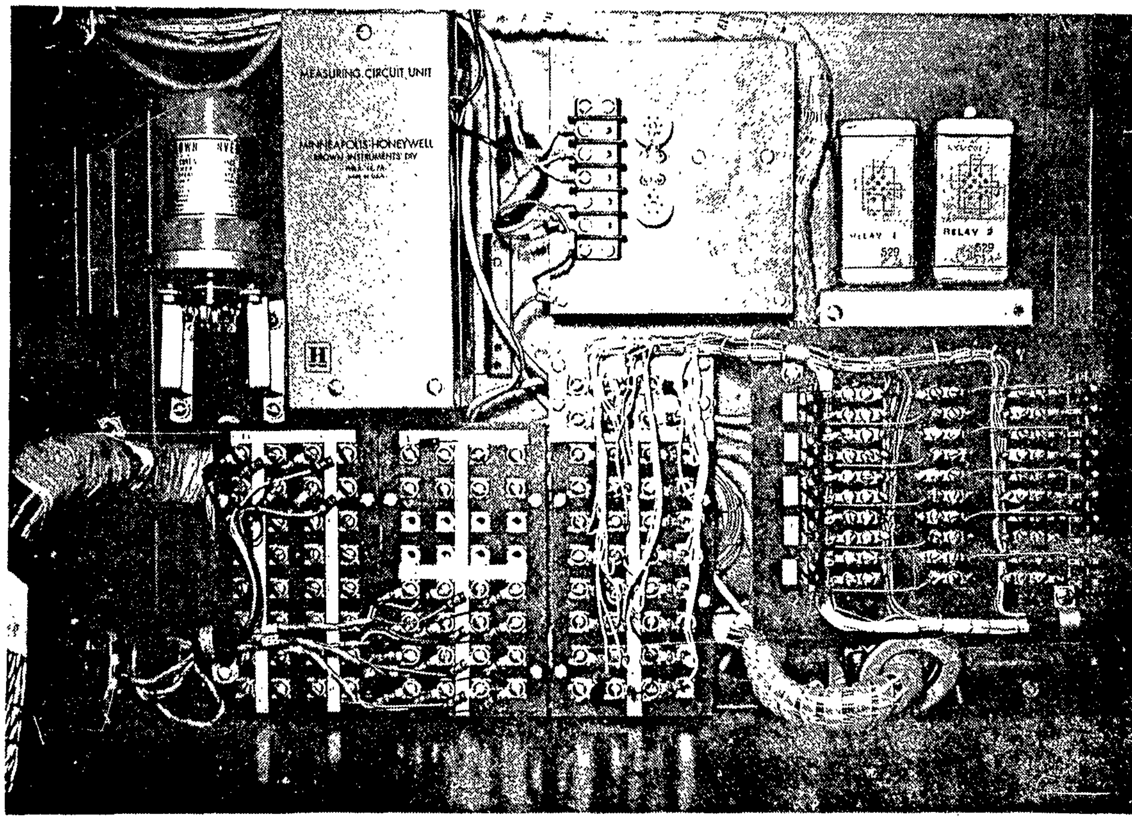



Figure 1. A view of the inside of the instrument showing the trimpots mounted to the right below the relays.

## ADDITION OF DC CHANNELS

A second major modification was carried out on the instrument which greatly increased its flexibility. This modification arose out of a need to have an ongoing record of the gas flows and gas composition in the system. Gas composition was obtained by two conventional Beckman analyzers[1], the infrared for carbon dioxide and the paramagnetic for oxygen. Gas flow was obtained from mass flowmeters of the thermopile type[2]. These instruments had very low impedance signals of the order of 5-10 millivolts, and it was decided to sacrifice four of the temperature channels for installation of potentiometric circuits for reading them.

As the instrument was received from the factory, all channels were excited with AC and the single AC amplifier was driven from a 34 ohm slidewire. An option was provided for converting all sixteen channels for potentiometric measurement. The desired modification for four potentiometric channels then became one of making the option permanent for four channels. The most practical method for accomplishing this was the addition of a second amplifier for DC and its slidewire which incidentally had a resistance of 20 ohms. The two amplifiers and the constant voltage unit were mounted in a case attached to the back of the instrument, shown in Figure 2. The DC amplifier, to the right is shown with its converter or "chopper".

Figure 3 is a view of the rear of the chassis showing the strip chart motor at upper center and below it, the back of five selector switches. One of these switches was wired to energize a relay which switched the DC amplifier to the balancing motor on Channels 1 through 4.

The modification was completed by changing the range resistors and trimming the balance of the measuring circuit unit for zero. The completed modification gives the following channels:

Potentiometric 0 - 10 mv, DC

1. Oxygen analyzer 0-8000, 0-200, 60-160 mm Hg
2. $CO_2$ analyzer 0-1% to 0-12%
3. Flow rate of gas in system cc/min.
4. Oxygen flow rate cc/min.

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1. Beckman Instruments, Fullerton, California

2. Hastings-Raydist, Hampton, Va.

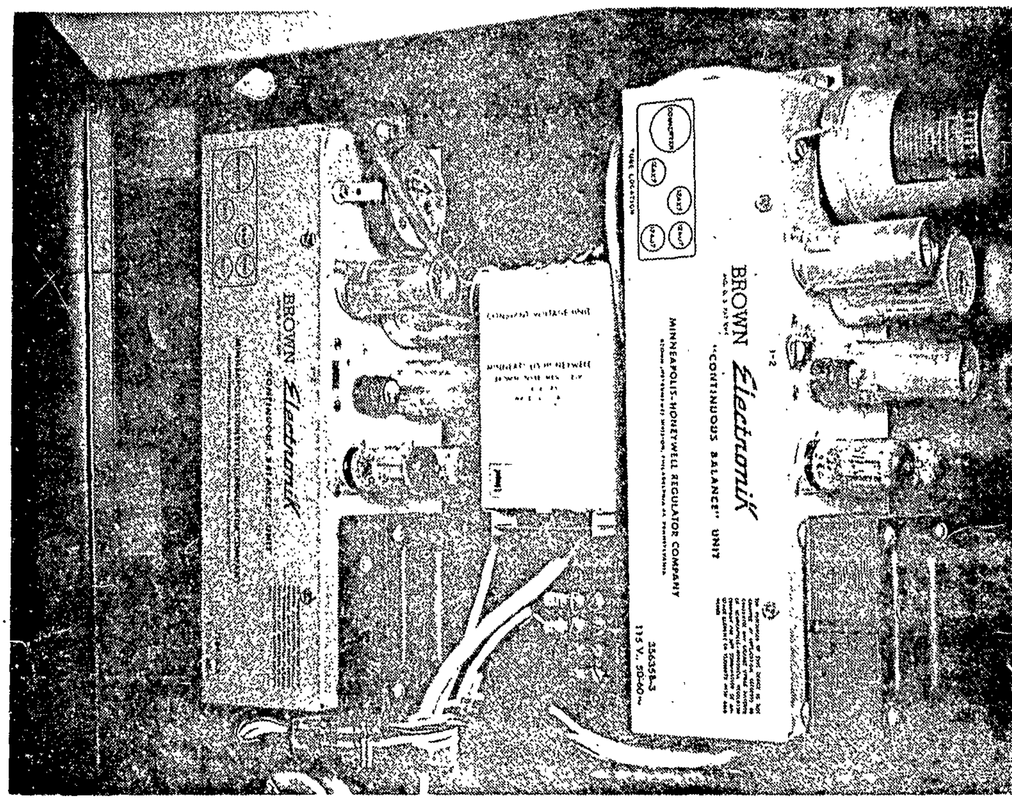


Figure 2. AC and DC amplifiers mounted in a case at the back of the instrument.

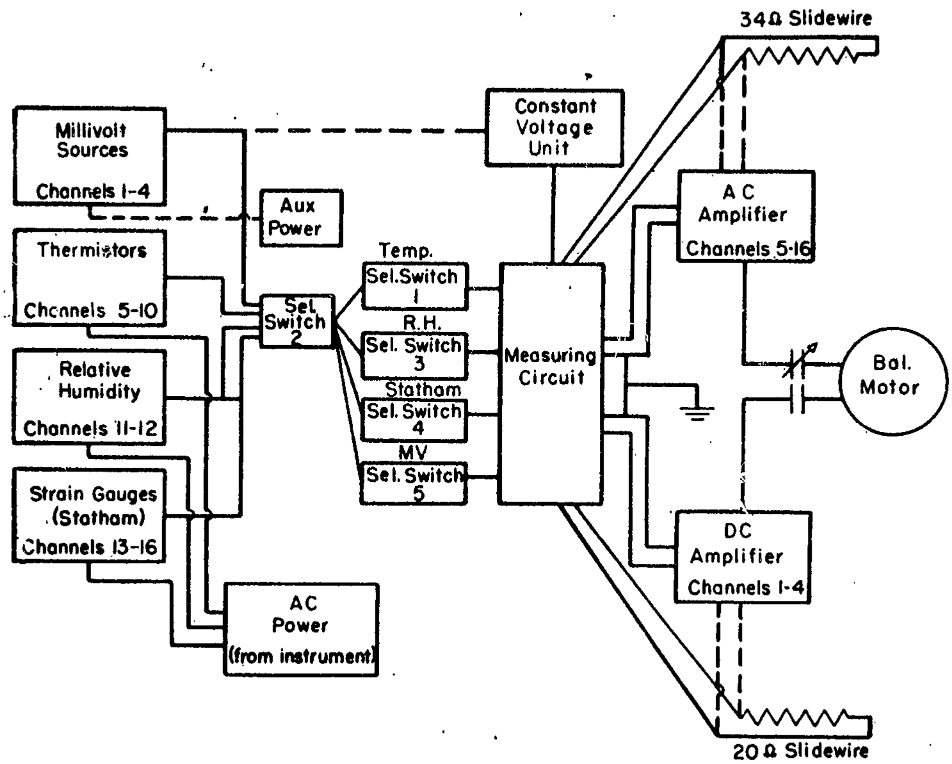


**Figure 3.** Functional diagram showing the operation of the recorder.

AC $Bridge_1$

5. Inlet temperature chamber 20° - 30°C.
6. Outlet temperature chamber 20° - 30°C
7. Inlet temperature scrubber 20° - 30°C
8. Outlet temperature scrubber 20° - 30°C
9. Wet bulb temperature 12° - 30°C
10. Room temperature 20° - 30°C

AC $Bridge_2$

11. Relative humidity outlet chamber 0-100 %
12. Relative humidity inlet chamber 0-100 %

Zero-span circuit AC

13. Pressure $O_2$ tank, 0-2000 PSI
14. Pressure chamber ± 15 PSI
15. Pressure chamber ± 1 PSI
16. Pressure analyzer ± 1 PSI

Figure 4 is a functional block diagram of the entire instrument. Power for operating the gas analyzers and the flowmeters is represented as auxiliary power to the millivolt sources. Switching from one group of channels to another and between the amplifiers is performed by relays wired to the selector switches.

In practice the gas analyzers are calibrated daily. The other channels are calibrated before and after a run since they are not accessible during the runs. The use of thermistors for measuring temperature lends itself well to changes in range for individual channels. These adjustments are made at the two trimpots for each channel. For ease of reading, five of the temperature channels were set for a range of approximately 20° - 30°C ± 1°. The sixth is a wet bulb reading, and its range was extended. from 12° to 30°C.

The instrument, as modified, allows one to measure any of the common variables associated with atmospheric environmental testing and is particularly useful where the duration of such tests is extended to weeks. Temperature, pressure, relative humidity and gaseous composition are provided for and each of the channels may be calibrated to suit the investigator.

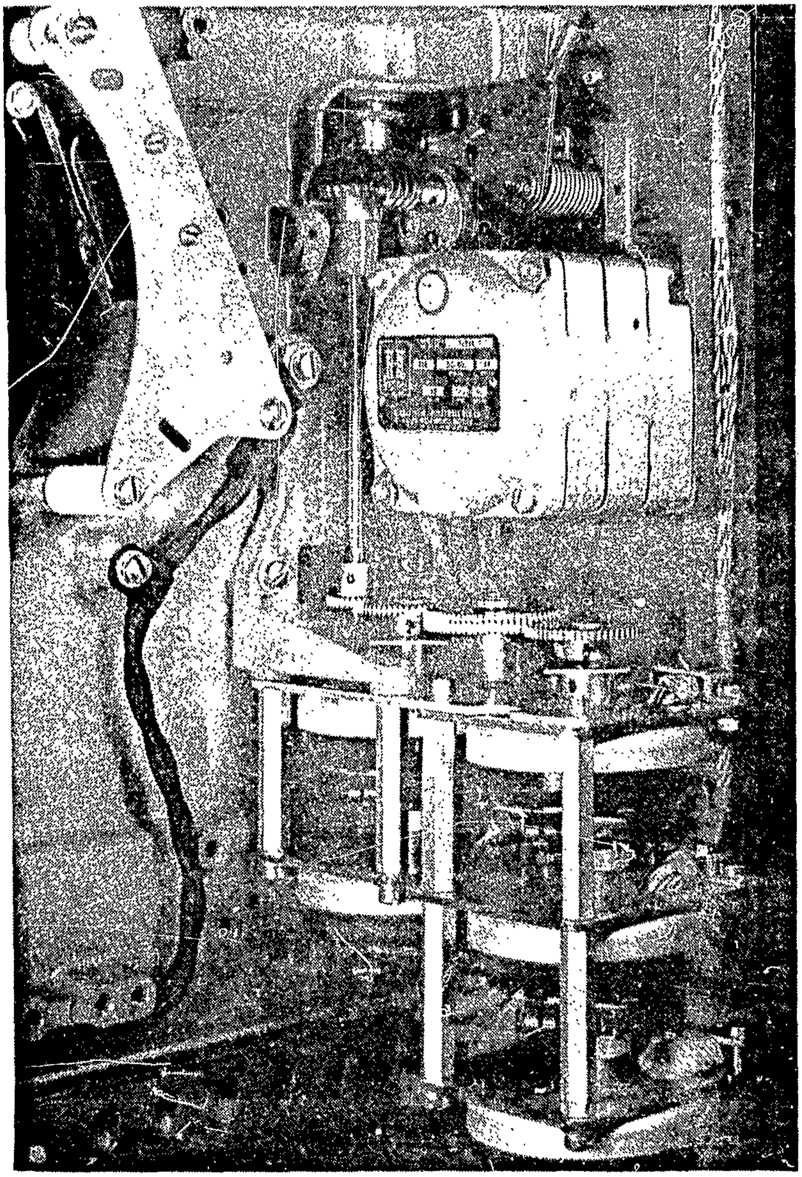

**Figure 4.** Chart drive motor and five selector switches.

## SYSTEM USES

The system operates well for its primary use — that of studying artificial environments and their effects on animals. Of primary interest has been the observation of atmospheric control mechanisms which include renewal of air in closed systems, maintenance of capsule pressure, etc. But of equal interest has been the study of animals under conditions which obtain in the isolated space capsule.

The controlled environmental system with data collection lends itself to the testing of instruments. Tests of relative humidity sensors have been carried out in the chamber where it was possible to control RH with solutions of inorganic salts, control temperature with the regulating system of the chamber while measuring wet and dry bulb temperature and the output from a number of RH sensors.

The system can also be used to study problems of general interest to biologists. Although one can find a large amount of information on the effects of a large variety of environmental conditions, there are some areas that have not been fully explored particularly with regard to the prolonged effects of artificial environments. Continuous monitoring and read-out make the investigation of such problems less difficult.

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